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DEEP-SEA SHRIMP TRAPPING FOR *Heterocarpus laevigatus* IN THE HAWAIIAN ARCHIPELAGO BY A COMMERCIAL FISHING VESSEL

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National Marine Fisheries Service
Southwest Fisheries Center

NOAA Technical Memorandum NMFS

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

The Mokihana was the most productive commercial fishing vessel in the offshore trap fishery for Heterocarpus laevigatus in Hawaii from 1983 to 1984. The Mokihana made 10 fishing trips from August 1983 to October 1984 and expended 208 days of fishing effort in the main Hawaiian Islands and the Northwestern Hawaiian Islands (NMHI) as far north as Gardner Pinnacles. Approximately 75 metric tons of whole H. laevigatus were landed in that fishing season, resulting in an overall catch per unit effort of 12.0 kg per trap-night. Mean catch rates for the main Hawaiian Islands (14.0 kg per trap-night) were higher than those for the NWHI (9.3 kg per trap-night). The trap loss rate was an estimated 3.35%. The statistics presented in this report provide a fairly comprehensive geographic survey of the relative abundance of H. laevigatus in the Hawaiian Archipelago. They can be useful for stock assessment and fishery management purposes and can also serve as a guide to participants in the deep-sea shrimp fishery.

CONTENTS

INTRODUCTION

Exploratory demersal fishing surveys by the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), NOAA, in 1967-68 indicated moderate quantities of two species of deepwater caridean shrimp, Heterocarpus laevigatus Bate and H. ensifer Milne-Edwards (Fig. 1), in the Hawaiian Islands (Struhsaker and Yoshida 1975). Further trapping trials were conducted through 1973 by the NMFS and the Hawaii Institute of Marine Biology of the University of Hawaii to obtain data on the biology and distribution of these Heterocarpus species (Clarke 1972a, 1972b; Struhsaker and Aasted 1974). Results of these experimental studies revealed a fishery potential for this unexploited resource and generated considerable interest in commercial shrimp trapping. However, early efforts to develop a deep-sea shrimp fishery in Hawaii were intermittent and on a small scale. Only eight small (<12-m) vessels participated in the fishery from 1970 through 1978; peak landings were 3.6-4.5 metric tons (t) in 1976-77 ([Hawaii] DLNR 1979). Exploratory fishing and gear development were major concerns for the fishermen during the late 1970's. At that time, fishing operations were generally unsuccessful because of small catches, gear loss, and marketing problems.

In the early 1980's, three major developments in research and industry contributed to renewed interest in a deep-sea trap fishery for H. laevigatus, the commercially preferred species. First, the NMFS, in a cooperative research effort with other agencies, engaged in the resource investigations of the Northwestern Hawaiian Islands (NWHI) from 1976 to 1982 (Grigg and Tanoue 1984a, 1984b; Uchida and Uchiyama 1986). Extensive resource assessment surveys were conducted, and deep-sea shrimp were among the principal species investigated. Seventeen banks were sampled from Nihoa Island to Kure Atoll (Fig. 2); previous studies had concentrated primarily on the main Hawaiian Islands. Based on those surveys, Gooding (1984) reported on the relative abundance and nearly continuous distribution of Heterocarpus spp. throughout the NWHI. This substantially increased the potential fishing grounds for the target species and suggested opportunities for long-range vessels. Second, with the conception of the Hawaii Fisheries Development Plan in 1979, it was estimated that an annual yield of 400-900 t of Heterocarpus spp. could be economically harvested in the Hawaiian Archipelago. This estimate spurred commercial interest in shrimp trapping in Hawaii, and several new vessels entered the fishery. Third, commercial-scale projects were funded in 1980 by the Western Pacific Program Office, NMFS (Hawaiian Divers 1983[1]), and in 1981 by the State of Hawaii in conjunction with the Pacific Fish Development Foundation (formerly Pacific Tuna Development Foundation) (Oishi 1983) to determine the economic

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[1]Hawaiian Divers. 1983. Deepwater shrimp utilization study for Hawaii. Report prepared under NOAA Cooperative Agreement No. 80-ABH-00065 for the Southwest Region, Western Pacific Program Office, Natl. Mar. Fish. Serv., NOAA, 2570 Dole Street, Honolulu, HI 96822, 48 p. [On file in NMFS Southwest Fisheries Center Honolulu Laboratory, Honolulu, HI 96822-2396.]

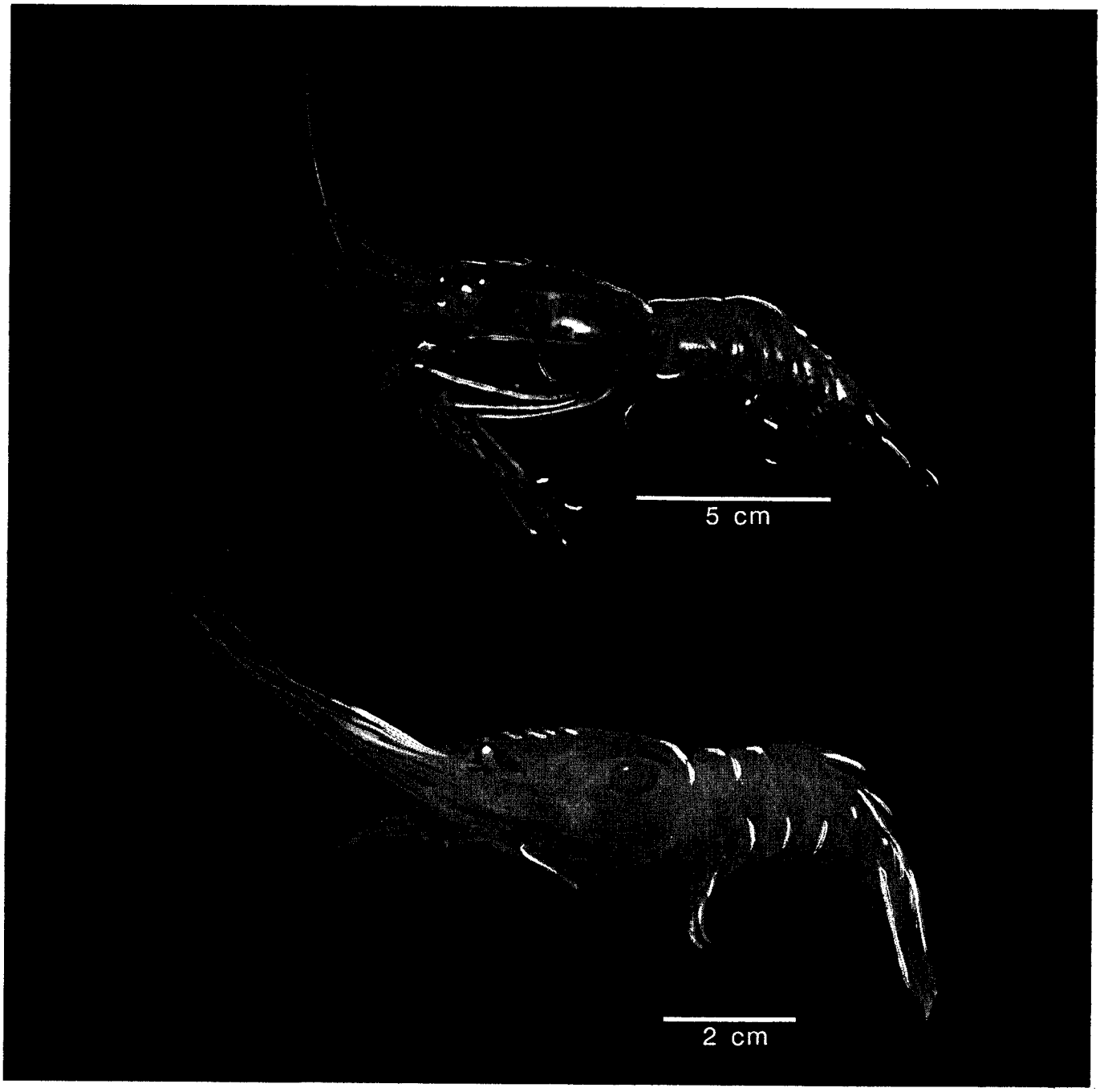

Figure 1.--*Heterocarpus laevigatus* (top) and *H. ensifer* (bottom).

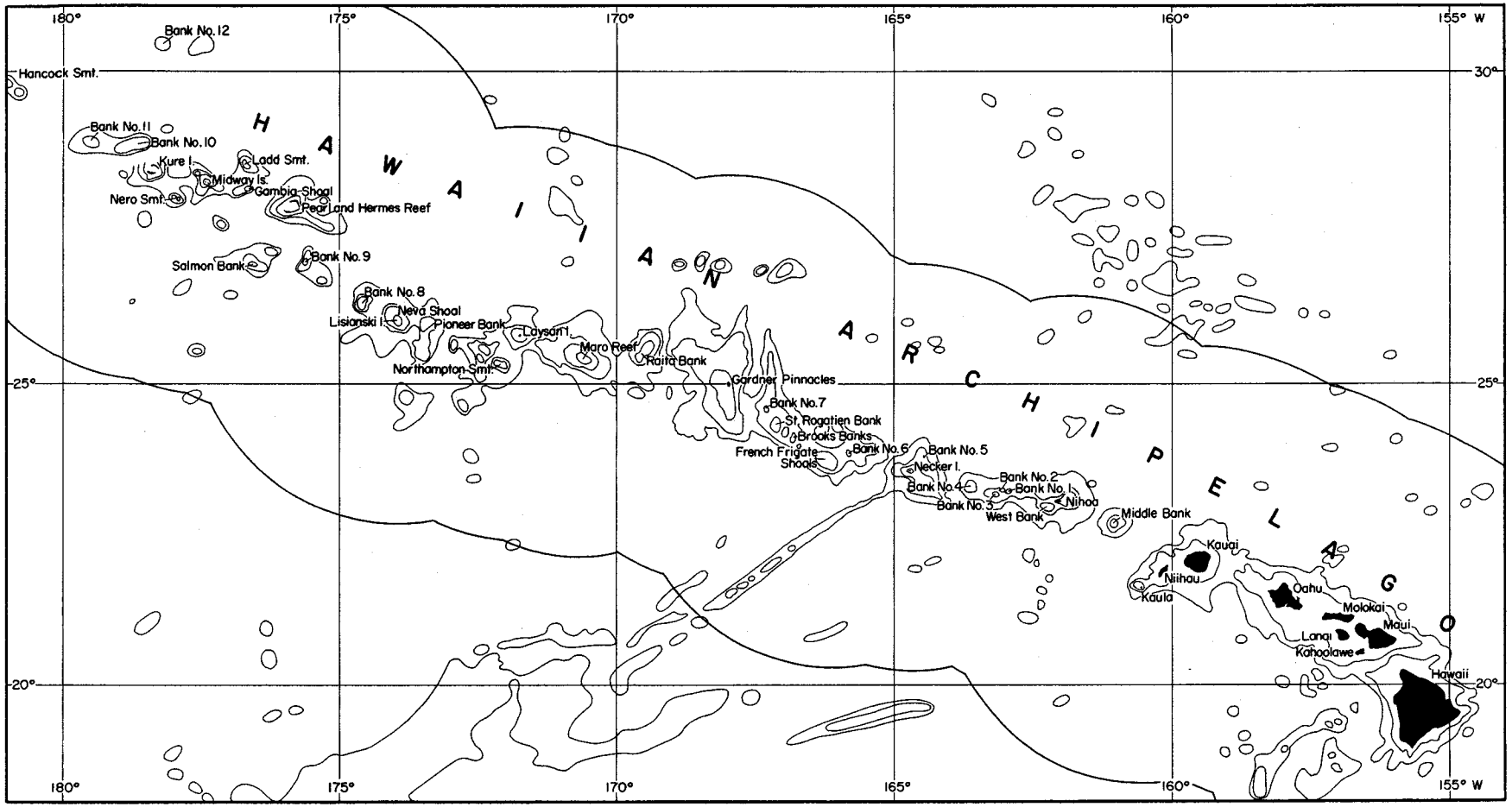

Figure 2.--The Hawaiian Archipelago including the Northwestern Hawaiian Islands. The approximate positions of the 100-, 1,000-, and 2,000-fathom isobaths and the U.S. Fishery Conservation Zone are shown on the map.

feasibility of shrimp fishing in Hawaii. These projects examined fishing and processing operations and conducted a market evaluation of the product. These three developments increasingly encouraged private interests to enter the fishery. The beginning of 1983 marked the start of a relatively large-scale shrimp fishery in Hawaii. By 1984, seven large (23- to 40-m) vessels and at least 10 smaller (<20-m) ones were actively fishing for deep-sea shrimp; approximately 159 t of H. laevigatus with an estimated ex-vessel value of $780,000 were landed in 1984 ([Hawaii] DNLR 1986).

The first major participant in this expanded fishery was the Easy Rider Corporation, which was influential in refining large-scale fishing and processing operations for deep-sea shrimp in Hawaii. Beginning in 1981, this company operated the Easy Rider Too (39-m catcher-processor) as a mother ship and employed two smaller (22- to 30-m) catcher-vessels, the Easy Rider and the Mokihana (Schlais 1982, 1983). The ability to process the catch at sea permitted longer fishing trips and potentially greater landings. However, because of high operating and capital costs, the Easy Rider Corporation experienced financial difficulties and was purchased by the Hawaiian Shrimp Company (HSC) in 1983 (Pacific Business News 1983). With the addition of another vessel, the Hawaii Makai (24 m), this new venture continued fishing operations through 1984. Although responsible for most of the State's shrimp landings, the HSC was still hampered by the difficulties and limitations of large-scale shrimp fishing in Hawaii. These problems included the high cost of production; difficulty in maintaining a high-quality product with a long shelf life; relatively low demand for frozen, whole shrimp locally; and development of export markets. In late 1984, the HSC decided to leave the fishery. Following these events, the NMFS Honolulu Laboratory was presented with the opportunity to examine the fishing logs of the Mokihana for the 1983-84 fishing season. With the consent and cooperation of Scott Barrows, captain of the Mokihana, the logbooks were released to the NMFS in 1986. These data are summarized and presented in this report.

TRAPPING GEAR AND OPERATIONS

The Mokihana was one of four commercial fishing vessels operated by the HSC and based at Kewalo Basin, Honolulu. It is 29.3 m in length, weighs 130 gross tons, and has a cruising range of 3,500 nmi. The vessel has circulating brine tanks (7,570-liter capacity each), which are kept at 0°C (32°F) for holding the catch.

The standard shrimp trap used by the Mokihana, as well as the other HSC vessels, was a large, pyramidal trap of steel "rebar" frame wrapped with galvanized wire mesh (1.27 x 2.54 cm (1/2 x 1 in)) (Fig. 3). It had a 1.83 x 1.83 m (6 x 6 ft) base, a vertical height of 96.5 cm, and a volume of 1.84 m^3. The sides of the trap were also covered with cloth made of synthetic fiber. The trap had a single, removable funnel entrance at its apex, with a 76.2 x 76.2 cm outer opening and a 14.6 x 14.6 cm inner opening. Bait cannisters were attached to a "rebar" arm that extended from the bottom of the funnel into the center of the trap. The funnel was secured to the trap with hooks and could be easily removed to empty the trap

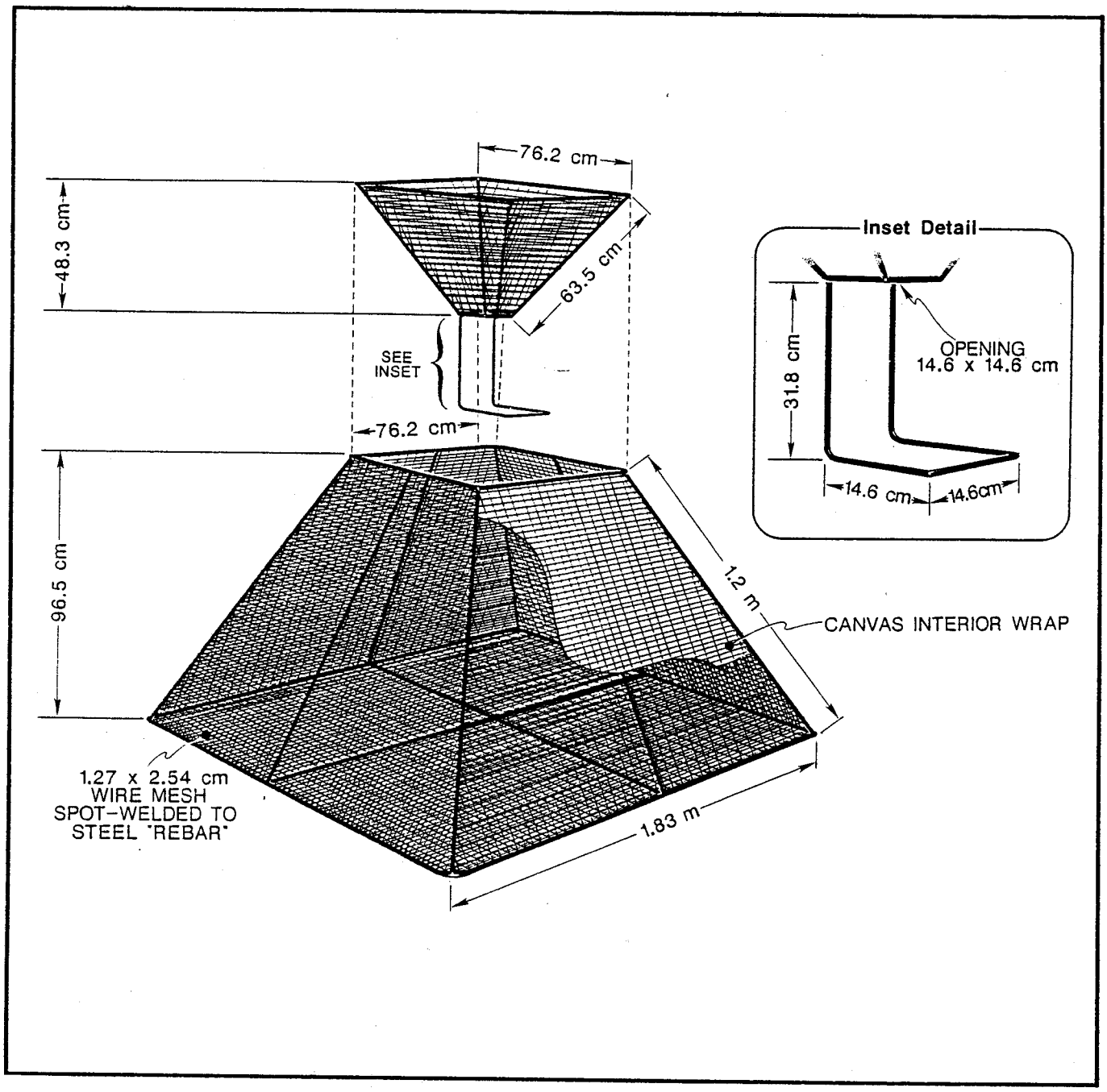

Figure 3.--The pyramidal shrimp trap used by the Mokihana and the Hawaiian Shrimp Company.

Figure 4.--A catch of Heterocarpus laevigatus being emptied from a pyramidal shrimp trap after removal of the funnel entrance.

contents (Fig. 4). Single traps were attached by 1.59-cm (5/8-in) polypropylene bridles to a 1.91-cm (3/4-in) polypropylene floatline, with a marker buoy at the surface (Fig. 5). The Mokihana can carry at least 50 of these shrimp traps.

The Mokihana used an ELAC[2] echo sounder to detect desired depths, bottom substrates, and signs of shrimp. After locating suitable trapping sites, the vessel set as many as 50 baited shrimp traps in the evening. The targeted depths were 549-640 m (300-350 fathoms), but trapping ranged from depths of 366 to 914 m (200 to 500 fathoms). Hauling of the gear started the following morning and continued throughout the day.

The catch was removed from each trap, and its weight was estimated volumetrically by the following conversion formula: kilograms of shrimp = 2 x liters of shrimp. The shrimp were then placed immediately into a circulating brine tank for chilling and holding. This operational routine was repeated daily throughout a fishing trip. The catch was routinely transferred to the mother ship for processing, packing, and freezing.

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[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

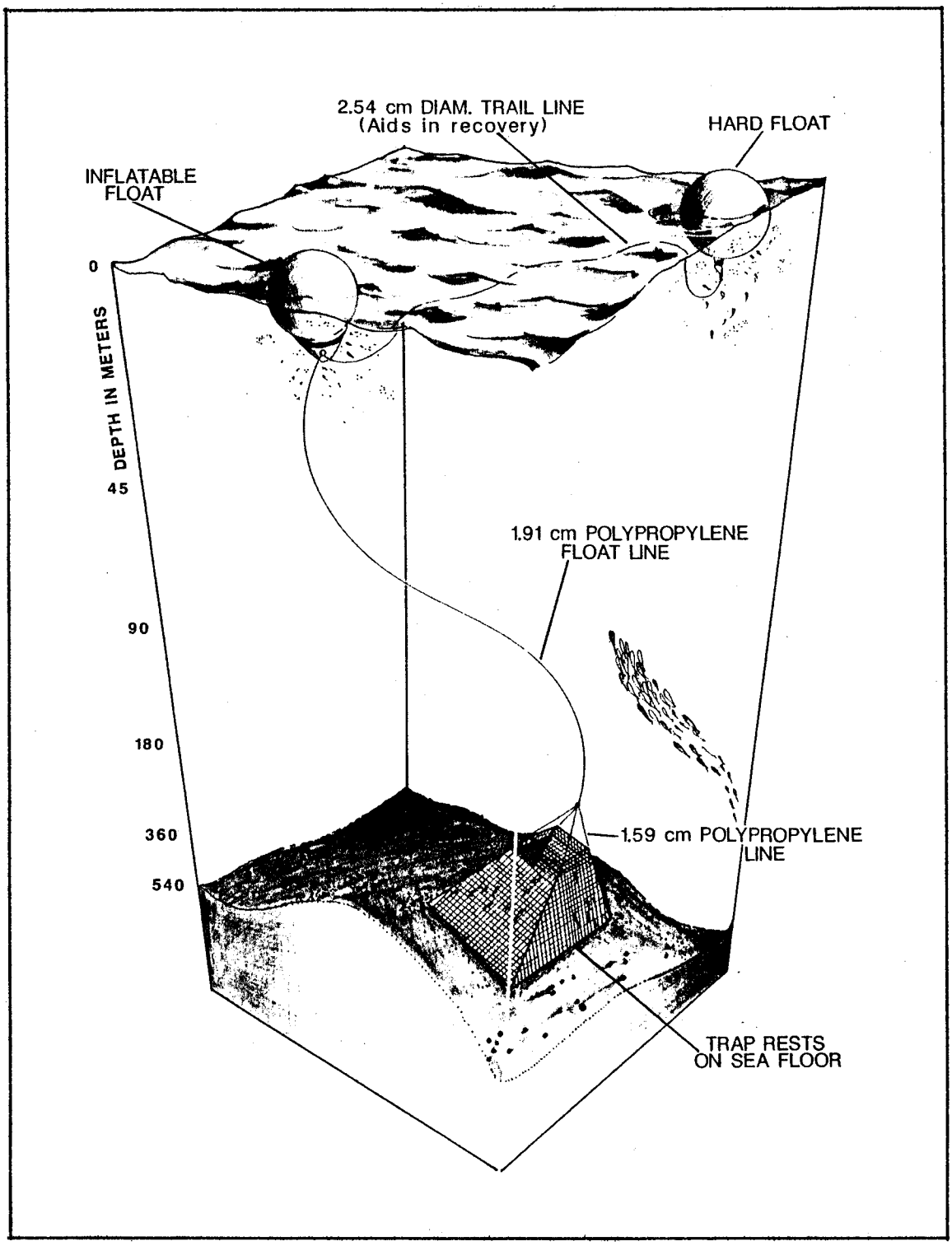

Figure 5.--The general arrangement of the shrimp trapping rig used by the Mokihana and the Hawaiian Shrimp Company.

RESULTS

Catch and effort data were extracted and summarized from the fishing logs of the Mokihana for August 1983 to October 1984. During that period, 10 fishing trips, totaling in excess of 250 sea days, were made in the main Hawaiian Islands and the NWHI. These trips accounted for 208 trapping days, not including traveling and nonfishing days at sea. Fishing trips varied in length from 4 d to 2 mo. Typically, trips around the main Hawaiian Islands were <1 mo, whereas trips to the NWHI were 1 to 2 mo long.

The Mokihana produced a total yield of at least 75 t of whole shrimp in that fishing season. The actual landings were probably greater because the total was based only on complete data records extracted from the fishing logs and did not account for the possibility of missing or incomplete entries. A total of 6,236 traps were fished, resulting in an overall catch per unit effort (CPUE) of 12.0 kg per trap-night (assuming all traps were hauled daily). The Mokihana, although capable of setting and hauling 50 shrimp traps per day, fished an average of 30 traps daily. The mean daily catch rate was nearly 363 kg per day, but ranged from a high of 1,282 kg per day (CPUE = 38 kg per trap-night) to <40 kg per day (CPUE = <2 kg per trap-night). The catch results for each fishing trip are summarized in Table 1.

Table 1.--Summary catch statistics by fishing trip for the Mokihana during the 1983-84 fishing season (CPUE = catch per unit effort (kg/trap-night)).

Dates	Days fished	No. of traps hauled	Total catch (kg)	CPUE
Aug. 1983	4	69	864.7	12.5
Aug. 1983	4	96	1,551.2	16.2
Sept.-Nov. 1983	40	935	10,888.8	11.6
Dec. 1983	13	369	4,295.8	11.6
Jan. 1984	5	153	1,618.7	10.6
Feb. 1984	8	224	6,349.0	28.3
Mar. 1984	22	719	14,930.2	20.8
Apr.-May 1984	29	693	7,337.9	10.6
June-Aug. 1984	51	1,734	17,553.0	10.1
Sept.-Oct. 1984	32	1,244	9,578.7	7.7
Total	208	6,236	74,968.0	12.0

The Mokihana fished at three different banks in the main Hawaiian Islands and seven different banks in the NWHI. These banks ranged from the Island of Hawaii to Gardner Pinnacles, more than 800 nmi to the northwest. Catch statistics for each bank are presented in Table 2. The catch rates ranged from a high of 17.1 kg per trap-night at Niihau, where 30.8 t of shrimp were taken, to a low of 2.9 kg per trap-night at Brooks Banks, where

Table 2.--Summary catch statistics by bank for the Mokihana during the 1983-84 fishing season. (Includes one fishing trip of the Easy Rider Too; CPUE = catch per unit effort (kg/trap-night).)

Location	Days fished	No. of traps hauled	Total catch (kg)	CPUE
Main Hawaiian Islands				
Hawaii	42	1,454	15,175.6	10.4
Oahu	15	370	4,772.2	12.9
Niihau	65	1,803	30,809.4	17.1
Northwestern Hawaiian Islands				
Nihoa	4	86	529.8	6.2
"Twin Banks"	26	724	7,026.9	9.7
Necker	10	297	2,497.5	8.4
French Frigate Shoals	62	1,570	16,060.7	10.2
Brooks Banks	2	56	163.3	2.9
St. Rogatien Bank	4	139	1,033.3	7.4
Gardner Pinnacles	11	375	3,020.1	8.1
Total	241	6,874	81,088.9	11.8

only 163 kg of shrimp were caught. The main Hawaiian Islands, which accounted for 63% of the total catch, appeared to be more productive than the banks of the NWHI, although the effort expended in each area was nearly the same. Fishing in the main Hawaiian Islands produced an overall catch rate of 14.0 kg per trap-night as compared to 9.3 kg per trap-night for the NWHI. French Frigate Shoals and "Twin Banks" were responsible for 76.1% of the total catch in the NWHI and had a combined catch rate of 10.0 kg per trap-night. Relatively little effort was expended at the five other banks in the NWHI; Nihoa, Brooks Banks, and St. Rogatien Bank received a total of only 10 d of trapping.

A trap loss rate of 3.35% was estimated from the fishing log data. This figure represents the likelihood that a trap will not be recovered after any individual set. This amount of gear loss seems reasonable to expect from trapping in Hawaii, although its accuracy is dependent on the completeness and uniformity of the data source.

It is of interest to compare the fishing results of the Mokihana and the Easy Rider Too during their September-October trip in 1984 (Table 3). Both vessels fished for virtually the same number of days on the same banks, but the Mokihana set nearly twice as many traps as the mother ship. It also

Table 3.--Comparison of the fishing results of the Mokihana and the Easy Rider Too in September-October 1984 (M = Mokihana, ERT = Easy Rider Too; CPUE = catch per unit effort (kg/trap-night)).

Location	Days fished		No. of traps hauled		Total catch (kg)		CPUE	
	M	ERT	M	ERT	M	ERT	M	ERT
Gardner Pinnacles	6	5	270	105	1,981.8	1,038.3	7.3	9.9
St. Rogatien Bank	2	2	95	44	542.1	491.2	5.7	11.2
Brooks Banks	1	1	34	22	60.3	103.0	1.8	4.7
French Frigate Shoals	11	11	425	210	2,956.6	2,215.4	7.0	10.5
Necker Island	--	1	--	17	--	120.2	--	7.1
"Twin Banks"	7	6	253	102	2,026.7	704.4	8.0	6.9
Nihoa	1	3	35	51	215.9	313.9	6.2	6.2
Niihau	4	4	132	87	1,795.3	1,134.5	13.6	13.0
Total	32	33	1,244	638	9,578.7	6,120.9	7.7	9.6

caught considerably more shrimp but had a lower overall trip CPUE of 7.7 kg per trap-night as compared to 9.6 kg per trap-night for the Easy Rider Too. The difference in vessel catch rates can probably be attributed to natural variation in shrimp density by area within a bank. Note that the greatest differences between CPUE for the two vessels occurred at banks where the total catch and the total effort were very low.

DISCUSSION AND CONCLUSION

The availability of commercial catch and effort statistics is of benefit to fishery managers, especially when used in conjunction with the findings of research surveys. Typically, the voluntary submission of commercial fishing data for use in research is an uncommon but much desired occurrence. It should be noted that this is the first time commercial shrimp trapping data have been made available to the NMFS Honolulu Laboratory for analysis. The analysis of data extracted from the Mokihana's fishing logs provided a fairly comprehensive geographic survey of the relative abundance of H. laevigatus in the Hawaiian Archipelago from the Island of Hawaii to Gardner Pinnacles. The results presented in this report are, thus, of value for the following reasons.

First, they provide a more realistic indication of the magnitude of the shrimp resources in the Hawaiian Archipelago than estimates obtained from previous research surveys (Gooding 1984). The commercial catch rates obtained from each bank can be translated into absolute estimates of exploitable biomass once the catchability coefficient is estimated (Ralston 1986). The results of an ongoing, intensive fishing experiment by the NMFS Honolulu Laboratory, using the commercial pyramidal shrimp traps at an isolated site

formerly fished by the Mokihana, will provide this estimate of catchability. Gear comparison experiments also can be conducted to standardize catch rates for traps of various sizes. This will allow comparisons of the NMFS research data (Gooding 1984), obtained by using a smaller shrimp trap, with the commercial fishery data based on the large, pyramidal trap. Standardization and pooling of the existing catch data would expand the available fishery data base and provide a more comprehensive assessment of shrimp abundance throughout the Hawaiian Archipelago.

The results in this report also provide baseline data acquired on a commercial scale for use in fishery management. Currently, the State has no rules or regulations pertaining to the harvesting of deep-sea shrimp in the Hawaiian Archipelago. Because of the heavy fishing of these shrimp in recent years and the continuing influx of vessels from the crowded fisheries on the U.S. west coast, the Western Pacific Regional Fishery Management Council (1984) believes that this developing shrimp fishery is in need of management action to prevent the harvesting capacity of the fleet from exceeding the estimated maximum sustainable yield.[3] It is fortunate that the data summarized here cover the first year of the large-scale shrimp fishery in Hawaii while the resources are still in good condition. It also points out the need to continue collection of commercial shrimp trapping data and to monitor the response of the stock to commercial harvest. Ideally, such operational and catch information will lead to proper recommendations to ensure optimum utilization of the shrimp resources.

Finally, the results presented here can serve as a guide to future participants in the shrimp fishery. These results are based on a full-scale commercial venture as opposed to the initial feasibility projects which were contracted previously by the NMFS and the State of Hawaii (Oishi 1983; footnote 1). The information provided is especially informative and relevant with regard to gear design, expected catch and revenue, and choice of fishing grounds. It is also timely in view of the continued interest in commercial trapping for deep-sea shrimp. Currently, local fishing effort has declined as compared to the years prior to 1985 when the fishing fleet of local and nonresident shrimping vessels was rapidly expanding. The larger vessels have exited the fishery but are being replaced by smaller ones.

Given the existence of substantial quantities of shrimp and their nearly continuous distribution throughout the Hawaiian Archipelago, there is a potential for a viable fishery for H. laevigatus. The demand for high quality shrimp products is strong, the required technology is available, and much can be learned from earlier research and commercial efforts. However, relatively high setup and capital costs are involved with deep-sea trapping operations. Additionally, problems experienced by previous ventures concerning fishing, processing, and marketing aspects of the fishery will require solutions. But in spite of the economic constraints to the development of this shrimp fishery, there is some room for optimism in Hawaii.

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[3]An estimated maximum sustainable yield of 830 t per year for the Hawaiian Archipelago was extrapolated from the yield estimate for the Marianas Archipelago (Moffitt and Polovina 1987).

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Appendix A.--Summary catch statistics by fishing trip and bank for the Mokihana during the 1983-84 fishing season (CPUE = catch per unit effort (kg/trap-night)).

Trip	Dates	Location	Days fished	No. of traps hauled	Total catch (kg)	CPUE
1	8/07/83-8/11/83	Oahu	4	69	864.7	12.5
2	8/17/83-8/21/83	Oahu	4	96	1,551.2	16.2
3	9/25/83-11/15/83	French Frigate Shoals (FFS)	40	935	10,888.8	11.6
4	12/01/83-12/22/83	"Twin Banks"	13	369	4,295.8	11.6
5	1/14/84-1/19/84	Oahu	5	153	1,618.7	10.6
6	2/10/84-2/21/84	Oahu	2	52	737.6	14.2
		Niihau	6	172	5,611.5	32.6
7	3/01/84-3/26/84	Niihau	22	719	14,930.2	20.8
8	4/17/84-5/19/84	Niihau	29	693	7,337.9	10.6
9	6/14/84-8/08/84	Necker	9	280	2,377.3	8.5
		Hawaii	42	1,454	15,175.6	10.4
10	9/08/84-10/21/84	Gardner Pinnacles	6	270	1,981.8	7.3
		St. Rogatien Bank	2	95	542.1	5.7
		Brooks Banks	1	34	60.3	1.8
		FFS	11	425	2,956.6	7.0
		"Twin Banks"	7	253	2,026.7	8.0
		Nihoa	1	35	215.9	6.2
		Niihau	4	132	1,795.3	13.6

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